HELIOPHYSICS
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HALEAKALA NEUTRON MONITOR REDEPLOYMENT FOR SOLAR NEUTRONS AND HIGH ENERGY COSMIC RAYS OBSERVATIONS.

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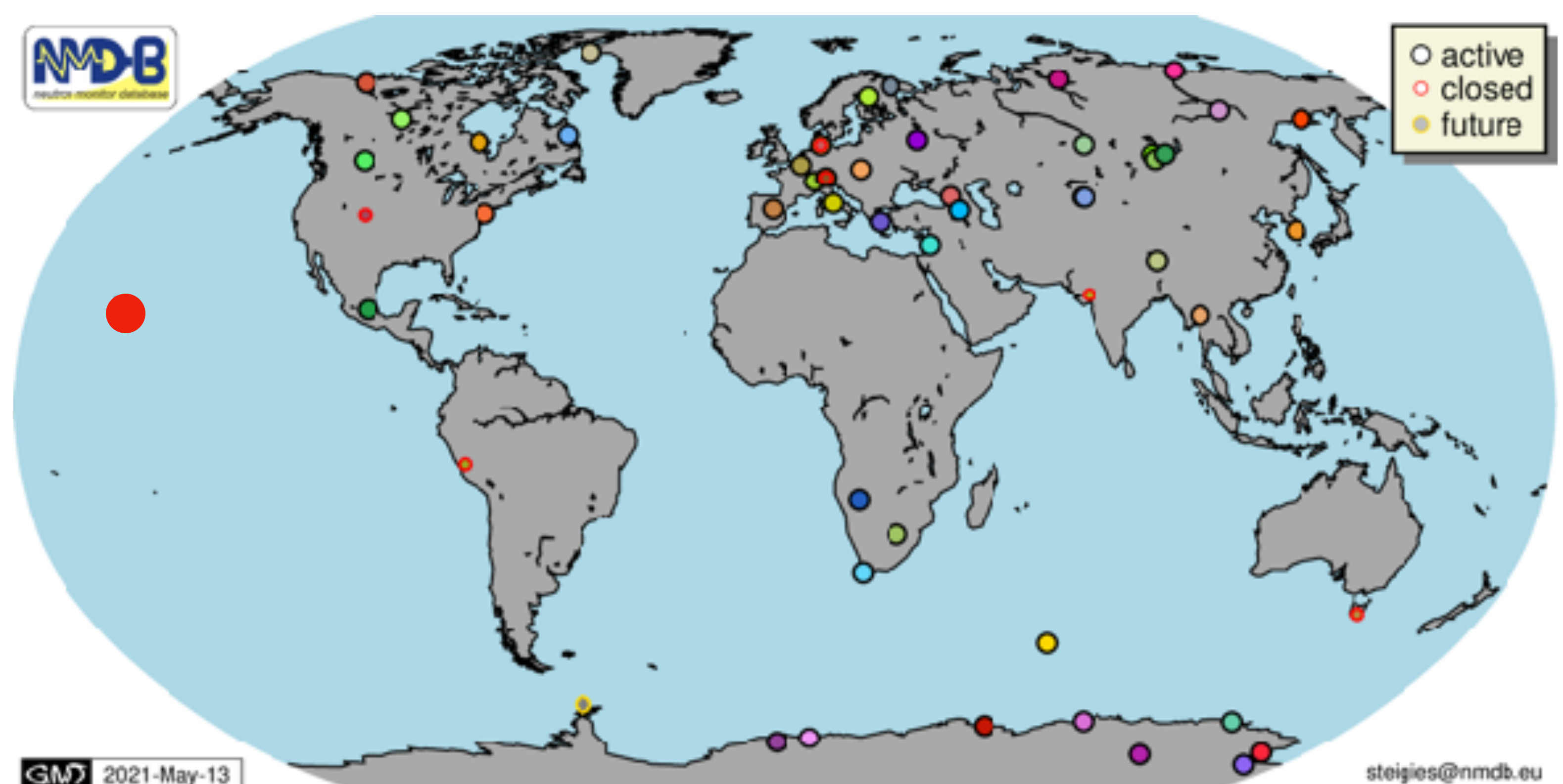
Redeployment of the Haleakala NM station (HLEA) on Maui

- The original NM station in Haleakala on the Maui island was constructed by the University of Chicago in 1991
- NM has been continuously taking data until its decommission in 2006, because of lack of funds.
- The Pacific Ocean represents a large gap in the equatorial coverage of the global NM network for SNP and CGR detection. Currently, this gap spans162 degrees from the NM in Thailand to Mexico City.

The red dot indicates the location of Hawaii



Motivations

- **Solar Neutron Particles** (SNPs) created in interactions of Solar Energetic Particles (SEPs) with nuclei in the Sun's atmosphere. Since SNPs are not affected by the interplanetary magnetic field, they retain direct information about the nuclear reactions happening near the SEP acceleration site. These new data will provide unique opportunities for future studies on energetic nuclear reactions and particle acceleration processes.

- There are only a few NMs in the global NM network in a favorable location for detecting SNPs. Haleakala position is ideal for SNP detection: the high-altitude minimizes particles absorption in the atmosphere, and the low-latitude maximizes the Sun's elevation, thereby increasing exposure. Original HLEA NM measured 3 solar neutrons.

- HLEA data will extend the **ground coverage of GCRs** with rigidity cutoff above 13 GV. This measurement is important for the 11- and 22-year solar cycle modulation, Forbush decrease studies, and for future works related to a direct comparison with the corresponding variations at lower energies.

Redeployment of the Haleakala NM station (HLEA) on Maui

- The HLEA NM would be relocated on the Haleakala summit on the island of Maui, at an altitude of about 3 km, (latitude 20.71 deg; longitude 203.74 deg; rigidity cutoff 12.91 GV).

- HLEA would be installed inside the original building.

- The original 21 proportional BP-28 counter tubes that were part of the previous HLEA NM.

- Same mechanical technician that assembled and decommissioned the old detector would assemble the new detector.

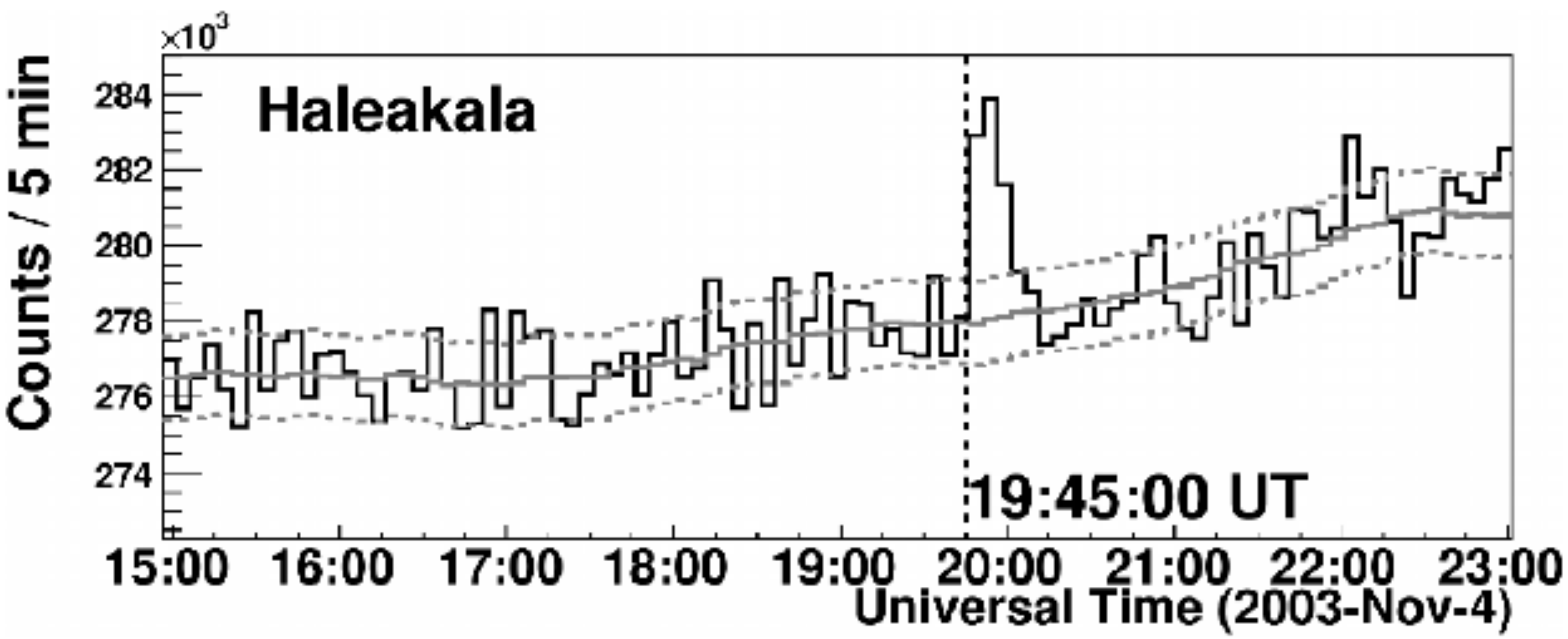
- Same configuration as Durham NM. Electronics from UNH.

Current status

- In the next four years we planned to redeploy this NM station upon availability of funds.
- Our baseline instrument is a six-tube NM-64, about five times the effective area of the Climax NM.
- The lead surrounding the tubes will have to be procured. Currently, lead prices are high for reason related to the ongoing COVID-19 pandemic crisis.
- The remaining unleaded tubes can still be used in the so-called ``bare'' configuration, as done for example in the South Pole station.

Scaled-down version of HLEA would still be sensitive to SNP

- A SNP event measured by Haleakala NM station in Nov 4-2003.
- The significance of the SNP excess reported in is 7.5 sigma If the number of tubes were to be reduced by a factor of three the significance would be of 4.3 sigma, a little bit less than the significance of the excess observed by the Mexico City NM for the same event.
- A scaled-down version of HLEA would still be highly sensitive to SNP events with amplitude of 2% or more over the background.



SNP measured by Haleakala NM station in Nov 4-2003

Five minutes average counting rate Smooth solid line is the average background and the dashed line is the +/- 1 sigma

Simulation of HLEA responses

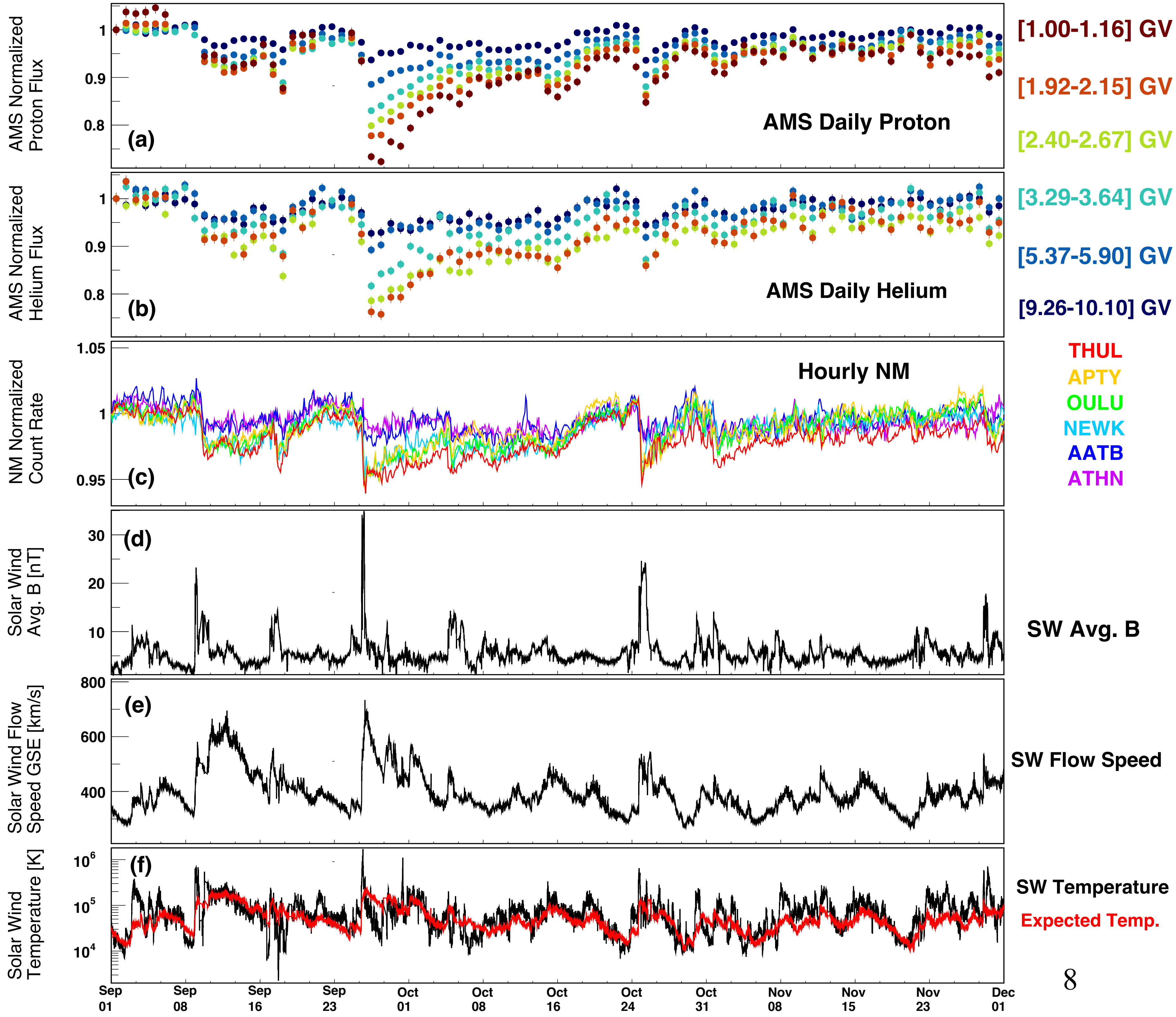
- The particle environment on Haleakala, and the instrument itself, differs from all other stations in the Simpson network.

- Assess the realistic, energy-dependent effective area of HLEA, the Yield Function, for both GCRs and SNPs, thorough simulation of the instrument and its surrounding environment, which includes the overlying atmosphere.

- The effect of different nuclei species on the NM response will be simulated. As primary particle spectra, we will use the published AMS fluxes of the most abundant GCRs species: proton, helium, carbon, and others from oxygen up to a high-Z component, such as iron. The final simulated response will be compared with data.

NM & AMS Comparison of GCRs and FD Study

Haleakala NM will provide count rates of high rigidity (> 13 GV) GCRs



AMS fluxes at different rigidities and for different particle species

Count rates of NMs at different latitudes

Conclusions

- The **redeployment of HLEA** will enrich the NM network and will **extend the ground coverage of GCR and SNP detection.**

- **SNPs** bring information about nuclear reactions occurring in the Sun's atmosphere during solar flares and SEP acceleration. These new data will provide unique opportunities for future studies on energetic nuclear reactions and particle acceleration processes.

- HLEA data will extend the ground coverage of GCRs with **rigidity cutoff above 13 GV.** This measurement is important for the 11- and 22-year solar cycle modulation, Forbush decrease studies, and for future works related to a direct comparison with the corresponding variations at lower energies.

- Bringing together direct measurements in space, especially by **AMS,** with those on the ground by **NMs** is important to understand the ground based measurements better.